

BUILDING SAND-CLAY ROADS IN SOUTHERN STATES.

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INTRODUCTION.

It is a matter of common observation that here and there in the Southern States are to be found stretches of sand-clay roads never known to be bad. This fact has led to a study of the reasons why such roads are always good. Numerous experiments have been made with varying results, but all indicate that the essentials to success in sand-clay road building are puddling and saturation. What is meant by puddling, or mixing, may be clearly understood by anyone familiar with the operations in the process of brickmaking. The clay must be rendered homogeneous, and this can be done only by the addition of water during the process until the clay becomes plastic like dough. The second essential is the addition of sand to the point of saturation, but not beyond. What is meant by saturation may be clearly understood by reference to fig. 24, which shows a magnified cross section of sand-clay composition as found in a substantial sand-clay road.

Let it be clearly understood at the outset that no sand-clay road can satisfactorily withstand the severity of public travel without having first been reduced to a compact homogeneous mass of sand and clay. Each grain of sand should be in touch with other grains on all sides (fig. 24). Such a condition can not be secured without the agency of water. It is useless to roll a dry sand-clay road before it has been rendered homogeneous by the puddling process and the grains of sand have been brought into contact, with only the interstices between them filled with clay as a binder. The first operation is mixing; the second is rolling as the mixture dries. This forces the particles of sand together, and any excess of clay tends to rise to the surface, rendering it sticky. This clay must in turn be sanded and the operations repeated until the surface has become hard and compact.

CAUSES OF FAILURES IN BUILDING SAND-CLAY ROADS.

Many failures have been made in the building of sand-clay roads, and a few of the more common causes for these failures will be pointed out.

IMPERFECT DRAINAGE.

The first cause of failure is the want of perfect drainage. The imperfections may be in the cross-sectional drainage, the side ditches, or the drainage of the subgrade or roadbed. It is customary to give to a sand-clay road a little greater crown than is usually given to a macadam road, especially where the grade is above 3 per cent. The subject of side ditches should have more careful consideration than is usually given in case of macadam roads. If the subsoil upon which the road is built is clay, it is important that the bottom of the side ditches should be 18 inches or more below the crown or middle of the traveled track. If, on the other hand, the land is rolling and the subsoil is sand of considerable depth, thus giving perfect natural drainage to the roadbed, little or no side

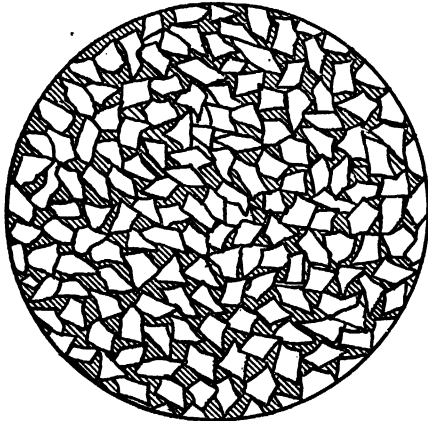


FIG. 24.—Clay mixed with sand to the point of saturation, the angular sand grains being in contact.

ditch will be required. Perhaps the most common error in drainage is the failure to drain properly and thoroughly all places where there are wet-weather springs. If necessary, the roadbed must be changed so as to locate it upon dry ground, as even the deepest side ditches practicable may fail to give relief where such springs exist. It is important to avoid deep cuts and to carefully consider all probable sources of trouble. The writer has often seen old roadbeds with water oozing from all parts during a rainy season, in spite of sufficient side ditches, the water even rising in the center of a 20-foot roadbed and standing on the surface, or slowly running along the wheel tracks to the nearest mud-hole. It should be remembered that water, beyond a very limited amount, adds nothing of value to the sand-clay road after it is completed. If water is always present, sand should be used without clay. Sand and water make a better road than sand and clay and water. In proof of this statement, attention need only be called to the numerous places where water crosses the roads in sandy districts. Such fords are always comparatively

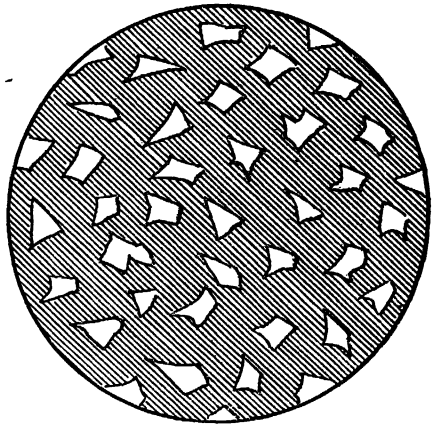


FIG. 25.—Sand-clay mixture with not enough sand, the grains not being in contact.

solid. On the other hand, where there is an excess of clay at such places there is apt to be deep mud.

It is easy to see why a road with the structure shown in fig. 24 will stand, wet or dry, while one with the structure shown in fig. 25 will fail, particularly in wet weather, because the clay when it becomes wet is plastic and the particles of sand, not being in contact with each other, are easily displaced, and in consequence of such displacement loaded wheels sink into the roadbed and destroy it. The remedy is clearly to add sand until the point of saturation is reached and the grains of sand come in contact with one another, assuming fixed positions.

INFERIOR MIXING.

Another cause of failure is the want of thorough mixing. There may be a proper amount of sand, and clay may be placed upon the road, yet if it is not thoroughly puddled and mixed to saturation in every place the road is not likely to withstand public travel. Some sections will break and become loose sand, while others will become muddy in wet weather and hard in dry weather. Such variations may occur every few feet and even at the same place, one wheel track being in loose sand and the other in mud. On one occasion the writer saw a street being torn up for macadamizing, because, as they said, the sand-clay mixture had failed to give satisfaction. The street was from side to side alternating holes and ridges, and practically worthless. When the material was torn up it could be observed that at least 50 per cent of the clay was in lumps from the size of an egg to that of a man's head, just as digged from the clay bank and dumped upon the street. The trouble resulted from too little sand and no attention to the mixing when the clay was wet and plastic. When ridges and holes began to form, more sand should have been added and all high places should have been leveled down to conform to the general contour of the street's crown. By this means uniformity of mixture would have resulted, and, when a sufficiency of sand had been added to saturate the clay for a depth of 10 inches and a good crown had been given to the street, all the traffic customary on such a thoroughfare would have been easily accommodated without mud or inconvenience.

FROST AS A DESTRUCTIVE AGENT.

In northern sections frost is another cause of failure and one more difficult to deal with than any heretofore mentioned. Frost is temporarily destructive to a sand-clay road, and for that reason the mixture must extend below the frost line if the road is built on a clay foundation. Freezing disintegrates the sand-clay composition and makes of it a soft, slushy mud, which, however, repacks again after each heavy rain, although frequently leaving the road surface somewhat rough.

Therefore, in general practice it is necessary to make the sand-clay mixture of such a depth as to extend a few inches below the frost line. It has been suggested that crude petroleum would be admirable in its effects upon this class of roads in higher latitudes; but so far as the greater part of the South is concerned the frost line is rarely more than 1 to 3 inches below the surface, and freezing to this depth does not seriously disturb the body of a sand-clay road, and as these frosts are only occasional they do not sufficiently disturb the road to make necessary the use of oil to prevent the absorption of moisture. Snow and sleet are also of rare occurrence and of short duration in the South, the surface of the road being soon exposed to the drying effect of the sun's rays, when it again becomes hard and resistant.

INFERIOR MATERIALS.

Failure is sometimes due to the kind of sand selected. None except sand made up of angular grains is adapted to sand-clay road making. Sand with grains which are worn off round, or sand which has been

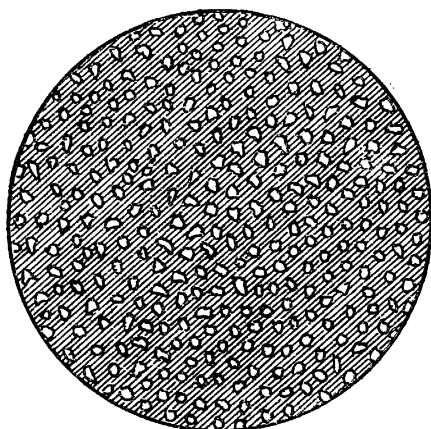


FIG. 26.—Unsatisfactory sand-clay mixture, the sand grains being worn round.

ground up by the action of wheels or water until very fine, is unsatisfactory and often worthless. The use of such material should be avoided, as a perfect bond can not be effected (see fig. 26), and the road can not resist the rolling action of wheels, the tendency being much the same as when pressure is applied to a mass of marbles. Care should always be taken to select the sharpest and cleanest sand that can be found.

Other causes of failure are the improper selection of clay and the improper treatment of the clay used. Ferruginous clays are the best, and chalky clays, as they are commonly known, are the poorest for road-building purposes. Some clays have a large percentage of sand to begin with and require less sand, while as a rule the chalky (sedimentary) clays have very little sand, or very fine sand, and are more difficult to get fully saturated with sharp sand so as to become unyielding and homogeneous.

Another cause of failure in the use of this particular clay is the fact that it rarely has iron enough to cement or bind the material together; hence it is easily broken up and washed away or blown away as dust.

LACK OF PERSEVERANCE BY THE ROAD BUILDER.

Another cause of failure is lack of perseverance on the part of the road builder. Probably more failures result from this than from any other cause. It must be borne in mind that building a sand-clay road is a process and not an instantaneous operation. The builder may fail when well within view of success. He must be guided by the manifestations. If clay is in excess, there will be a tendency to form mud in wet weather; if sand is in excess, the tendency will be to break up into deep sand during the dry seasons. There is a sufficient middle ground between these two extremes to permit of wonderfully improving the deep sand roads of the South and greatly bettering the clay roads of the Piedmont section.

HOW TO USE AVAILABLE MATERIAL.

As the road builder is forced to use such sand and clay as is available, he should learn to build the best possible road with the material to be had; hence the chief object of this paper is to show how the material may be used to the best advantage. There are many localities in the Southern States where sand very largely predominates, and the only clays to be found are sedimentary, often carrying a large percentage of very fine sand and scarcely any iron at all. It is usually difficult to build a really first-class road of this material. The first step should be to make the roadbed at least 20 inches above standing water in the ditches. This must be carefully attended to if the country is level and the drainage poor. No road of any kind is likely to prove satisfactory unless drainage of the roadbed is carefully provided for, and especially is this true of a sand-clay road made of sedimentary clay and fine sand. Possibly more depends upon the sand selected than upon the clay. The coarser the sand, the better the road will stand. Wherever the road shows a tendency to break in dry weather, more clay should be added.

EXAMPLES OF GOOD SAND-CLAY ROADS.

It may not be amiss to point out by way of encouragement a few of the many places where most excellent roads have been built of sand and clay, which are to-day the equal of macadam roads costing many times as much.

Pl. XXX, fig. 1, gives a view of a road in Richland County, S. C., about $3\frac{1}{2}$ miles from Columbia. This road is known as the Garners Ferry Road, and has been in use under the heaviest travel for five years without any repairs. It was originally very deep sand. It was built about 32 feet in width between ditches and sustains an enormous daily travel, much of which is very heavy, and narrow-tired wagons are commonly used. Nevertheless, the surface is, as shown in the illustration, free from ruts, hard, and smooth.

Pl. XXX, fig. 2, is a view of a sand-clay road built under the supervision of the Office of Public Road Inquiries just outside the corporate limits of Newbern, N. C., about fifteen months ago. This roadbed, which is less than 15 feet above mean tide-water level, was of the deepest and finest sand, and the clay used was sedimentary and of very ordinary cementing properties. The road was laid out 30 feet wide and crowned to a height of 12 inches above the ground surface, the ditches being cut about 12 inches deep at the outside edge and 3 feet wide. These ditches were sloped from the roadside toward the outside. The ditches do not show in the illustration, because they have been allowed to become overgrown with grass and weeds, not having been cleaned off since the road was built. This road is used by some of the largest truckers around Newbern, and many thousands of cartloads of truck are hauled over it each season. This Newbern road was reported upon as follows last June by Mr. William Dunn, who used it very largely last winter and spring:

I am in receipt of your letter of recent date asking about the sand-clay road. It has worn remarkably well through the winter, requiring but little work; in fact, the first half of the road has needed only to be scraped. The portion of the road last finished was quite bad at first and remained so for a long time. It was sanded and resanded and scraped, and it finally settled and became hard, and is now, and has been for some time, in good condition. The part nearest town has never given any trouble. I think the material used was of just the proper consistency, there being sand enough in it to prevent cutting.

The part of this road nearest the town, where the road was begun and which Mr. Dunn says has never given any trouble, is shown in Pl. XXX, fig. 2. It should be remarked that there is scarcely any place where conditions could be more unfavorable, and still this road has more than doubled the hauling capacity of the truckers living along the line. This means to them a vast saving, because truck has to be so rapidly handled when in season that many teams have to be hired from the town. In consequence of this improvement fewer teams are needed in the delivery of truck to the railroad.

At Tarboro, N. C., another section of sand-clay road work was done under the direction of the Office of Public Road Inquiries. Pl. XXXI, fig. 1, gives a view of this road, showing nearly one-fourth mile of it. Although no work has been done upon this road since its construction more than a year ago, it can be clearly seen that it is a good road. It is hard and smooth, except for slight depressions where the wheels have worn and packed the roadbed and where a central track has been formed by horses. This central track is due especially to the fact that carts are mainly used for hauling commodities, and to the further fact that the road was neither properly crowned when it began to dry nor kept in shape when finally packing and drying. This road needs only scraping and a little more sand added in places. It was made of sedimentary clay and ordinary sand. The clay had to be hauled a distance



FIG. 1.—GARNERS FERRY ROAD, 3.5 MILES FROM COLUMBIA, S. C., USED FIVE YEARS WITHOUT REPAIRS.



FIG. 2.—SAND-CLAY ROAD BUILT AT NEWBERN, N. C., UNDER THE DIRECTION OF THE OFFICE OF PUBLIC ROAD INQUIRIES.



FIG. 1.—SAND-CLAY ROAD AT TARBORO, N. C.
[Nothing has ever been done to this road since it was constructed.]



FIG. 2.—VIEW 3 MILES NORTHWEST OF COLUMBIA, S. C., ON THE WINNSBORO ROAD,
NEAR HYATTS PARK.

of about one-half mile on an average. The grass and weeds which have grown up and filled the ditch show neglect. There are about 2 miles of this road, and a part of it became very muddy last winter and will become so again unless heavily sanded. This locality has loose sandy loam and very fine-grained sand, a part of which is free from loam. The latter will make in the end a good road, but patient, persevering effort is necessary to secure the best results.

The Newbern and Tarboro roads have been specifically pointed out because they show what can be done under maximum difficulties, being made of exceedingly fine-grained sand and sedimentary clays of poor binding qualities. The Columbia road shown (Pl. XXX, fig. 1) is made of an average quality of clay and sand, the former possessing good binding qualities and the latter being clean and fairly sharp. Another Richland County road is shown in Pl. XXXI, fig. 2. This is a section of the Winnsboro road about 3 miles from Columbia and near Hyatts Park. This road has been in use for more than five years without repair and presents a high degree of excellence, comparing favorably with the best macadam road in Mecklenburg County, N. C., in point of durability and utility. It is made of an excellent variety of ferruginous clay, water-worn quartz pebbles, and sand. The superior binding qualities of this clay, together with the sand, firmly embed the pebbles, and they are not displaced by the severest usage.

In a report on the roads of Richland County Mr. S. H. Owens, of Columbia, S. C., wrote as follows:

In reply to your letter of the 12th instant, requesting a detailed account of my experience in building sand-clay roads in this (Richland) county, I will say that the necessary quantity of sand on clay or clay on sand has to be determined by experimenting. When the road has been properly graded, and the roadbed is of sand foundation, the clay is spread evenly over the surface to a depth of from 4 to 6 inches, the depth depending on the percentage of sand in the clay. If the roadbed is of clay foundation, the sand is spread on a little thicker, say, from 6 to 8 inches. The clay or sand is simply spread on, not mixed, and the mixing is done by travel over the road, which is not interfered with while the road is in course of construction.

I find, after thoroughly experimenting, that sand on a clay foundation does not give as good results as clay on sand, on account of the drainage being insufficient under the roadbed, the clay not being as porous as sand.

As to the durability of the roads treated in this manner, I will state that roads which were built five years ago are in as good condition now as when built, and in some instances better. Of course, the roads have to be run over occasionally and repaired, which is quickly and easily done. Sometimes where there is much travel over the roads small holes will wear in them, owing to lack of clay or sand at that particular point. I find this to be the case near Columbia, where travel is necessarily greater than in the remote sections of the county. There are some roads in the county constructed five years ago that have had no repairs and are now in first-class condition.

We have about 400 miles of road built by the sand-clay method out of a total of about 650 miles in the county. These roads are giving perfect satisfaction and have stood the test of hard rains and constant travel. The cost of constructing roads by this method depends on the amount of grading to be done and the distance the sand or clay has to be hauled. The cost of repairs is very slight.

CONCLUSIONS.

The building of sand-clay roads has passed the experimental stage, and it is no longer a question of doubtful procedure. The important things to be borne in mind are thorough mixing to the saturation point, and then properly shaping and rolling the road. This mixing is usually done by the traveling public. This is the critical period in the construction of a sand-clay road, because care must be taken to secure an even amount of puddling, so that all the lumps of clay shall be broken and saturated with sand to a depth of 8 to 10 inches. If this can be done and the road is properly crowned as it dries, there can be no doubt about the result being eminently satisfactory. This mixing might be done by the use of plows and harrows when the clay is wet; but it is customary to let teams and vehicles accomplish it. It is true that the condition of the road becomes worse for a while during the puddling operation; but after this is effected and sufficient sand has been added relief is permanent.

In many portions of the Southern States the public roads are maintained by the old system of statute labor, which has been reduced, by the inefficiency of overseers, to little better than worthless. The mud which it is customary to throw on the roadbed is often a detriment, as it is the worn-out material from the road that has been gradually accumulating in the ditches. There are many sand-bars and gravel beds along the streams and rivers of the Piedmont section, where unlimited quantities of good sand and gravel may be found, a few loads of which would permanently heal the worst mudhole if it were to be first thoroughly drained. There is need of a general awakening along this line everywhere. An enormous waste of labor results, as stated, from the incompetency of many of the road overseers. Whether the overseers work statute labor, commutation labor, or hired labor, they should be able to so treat each particular case, deep sand or deep mud, as to effect a permanent cure.